004411

Associated Students of

Utah State University

Guest Lecture by

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Administrator

National Aeronautics and Space Administration

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EXPLORING THE SOLAR SYSTEM -- 1974 THRU 1991

and

THE SEARCH FOR EXTRATERRESTRIAL LIFE

Introduction

The National Aeronautics and Space Administration has a strong, realistic, and highly rewarding national space effort planned for this decade and the next.

Our current programs are working out very well. We have had some notable successes. Here are some examples:

Current Programs

-- Skylab, America's first space station and Man's first home in space, has been an outstanding achievement.

-- Pioneer 10 stirred the imaginations of millions of people around the world as it passed close to the giant planet Jupiter in December.

-- Mariner 10 has passed Venus and will fly by the innermost planet Mercury on March 29.

-- Our most ambitious scientific satellite to date, the Orbiting Astronomical Observatory named for Copernicus (OAO-3) has produced evidence of the existence of a Black Hole here in our own Milky Way Galaxy.

-- Our first Earth Resources Technology Satellite, ERTS-1, has proved to be a valuable new tool to help manage the world's resources and protect the environment.

-- The worldwide effort to study Comet Kohoutek, which NASA helped to coordinate, has produced valuable results and stirred public interest in comets, even if Kohoutek was not seen by very many people.

These current achievements give you some idea of the broad range of NASA's activities today -- activities which range through the spectrum of modern scientific endeavor, from measuring the drifting apart of the continents at about <u>one inch per year</u> to <u>searching for life</u> elsewhere in the solar system.

Range: Tectonic to Life Search

1973 NASA Payload Model

We have recently completed an important new planning exercise at NASA. We have drawn up a document we call the 1973 NASA Payload Model which shows with some precision the number of payloads, and the kinds of payloads, we might reasonably expect to send to Earth orbit and farther out into the solar system each year from now through 1991.

Our planning that far ahead is still quite tentative, as it should be, but I can still give you a good idea of the shape of the future in space through 1991. And we have been quite realistic about the cost, because the NASA payload model I am talking about assumes a level of expenditures at about the current level -- that is, around $3.2 or $3.3 billion dollars per year, adjusted as necessary for inflation.

SHAPE OF FUTURE

Six Major Areas of NASA Activity

To help organize my remarks today, I would like to identify six major areas of NASA activity. We won't have time to discuss them all, but I do want you to know about each of them.

One. We will continue to explore throughout the Solar System with automated spacecraft (that is, unmanned spacecraft); and one of the main aims of this exploration will be to find evidence of extraterrestrial life, or at least a better understanding of how life arose on Earth.

SOLAR SYSTEM

Two. We will intensify our use of spacecraft in Earth orbit. Some of these spacecraft will look back at Earth and some will study the Sun or look far out into the Universe. Some will seek scientific information, some will produce practical benefits.

EARTH ORBIT
A. Astron.
B. Earth

Three. During the remainder of this decade we will concentrate much of our effort on developing the Space Shuttle transportation system, which is a better and cheaper way of getting manned and automated payloads to Earth orbit and back. We will also be working closely with a group of nine European countries which is developing a manned Spacelab module to be carried to orbit and back in the Space Shuttle.

SHUTTLE

Four. In addition to developing the Space Shuttle in this decade, we are planning and developing the improved payloads for the Shuttle to launch and service in the 1980s and 1990s. These payloads will include large automated observatories and a wide range of experiments and practical tasks to be performed in the manned Spacelab module. SHUTTLE PAYLOADS

Five. NASA has a strong program in aeronautical research to help meet national needs in this important field. Our main responsibility is to help identify and meet the research needs of civil aviation, but we also work closely with the military services. AERO

Six. We also have a number of programs to demonstrate how new technology developed in the space program can be used to meet national needs outside the aerospace field. For example, we already know a great deal about how solar energy can be harnessed or how hydrogen can be used as a fuel. NEW TECH (ENERGY)

For a number of reasons, I have chosen to concentrate today on exploring throughout the Solar System and the search for extraterrestrial life.

SOLAR SYSTEM + LIFE SEARCH

First. I have found these are subjects of especial interest to university audiences.

WHY?

Second. Our efforts to explore the planets and study comets are producing interesting results at the present time.

Third. We need broader public understanding of the reasons for exploring the planets, and universities are certainly one of the key places in our society where this understanding should be generated.

Outer Planets: Pioneer 10

Let's start with the Outer Planets, and the remarkable voyage of Pioneer 10.

Pioneer 10 has travelled farther from the Earth and flown faster than any other man-made object. Its speed at launch had to be more than 32,000 miles per hour. That is why we were already 15 years into the Space Age before the first voyage to the Outer Planets was attempted.

Significant advances had to be made in spacecraft and rocket technology and space communications before a spacecraft like Pioneer 10 could be launched.

For example, it flies so far from the Sun that it cannot rely on the solar cells used to provide electrical power for other spacecraft. It is the first NASA spacecraft to rely solely on nuclear energy for the electrical power needed for its communications equipment and other instruments.

NUCLEAR

This small spacecraft, weighing only 570 pounds, passed Jupiter exactly on target, with all instruments working, after a voyage of 641 days and more than 500 million miles.

641 DAYS

It not only passed Jupiter on target, its arrival was so precisely timed, within a minute or two, that it passed behind one of the moons of Jupiter -- the moon Io -- for important occultation observations. 1 MIN. IO

Moreover, Pioneer 10 sailed through the intense radiation zones of Jupiter without significant damage. The radiation was stronger than expected, Pioneer's margin of survival was apparently small, but it came through with flying colors. RADIATION

The gravity of Jupiter increased Pioneer's speed to 82,000 miles per hour. This speed will permit it to escape the Sun's gravity and sail on through interplanetary space until it is captured by the gravity of some distant star. ESCAPE

Pioneer 10 is still reporting on the interplanetary environment. We expect to keep in touch with it until it passes the orbit of Uranus some time in 1979. By then it will be nearly two billion miles from Earth. URANUS 2 BILL

Sending radio commands to Pioneer and getting back color images of Jupiter and data from the 10 other major scientific instruments aboard has been a tremendous communications achievement. 10 INST.

Keep in mind that Pioneer's antenna must always be pointed toward Earth for successful communications.

Keep in mind that Jupiter's radio transmitter draws only eight watts of power to begin with, and that these signals are weakened to only a tiny fraction of a watt by the time they reach Earth. [For the engineers in the audience, this tiny fraction of a watt is 10^{-12} or less. That's one quadrillionth or less.]

8 WATTS

Keep in mind that these infinitesimal signals must be picked up by one of NASA's three big-dish antennas in California, Spain, or Australia, separated from all the radio noise of space, and amplified to readable strength.

3 DISHES
(85 m)
210 FT.

Then consider that some of these signals, when enhanced through a special computer process at the University of Arizona, have produced color images of Jupiter with significantly more detail than can be seen through the best telescopes on Earth, and you will see why I consider Pioneer 10 one of the most remarkable creations of the Space Age.

PROCESS
PICTURES

What have we learned from Pioneer 10?

Articles are beginning to appear in the scholarly journals. The magazine Science for January 25 had a good preliminary round-up of results. Further disclosures will be made at a comprehensive press briefing at NASA Headquarters in April.

When all the results are in, we are going to know a great deal more about Jupiter and its moons than we did before, and it is likely we will also know much more about how Jupiter and the other planets of the Solar System were formed.

One of the first important findings of Pioneer 10 has been that the Asteroid Belt is not a significant hazard to navigation. Despite some early fears on this subject, we are definitely not walled in from the Outer Planets. This finding and Pioneer's continued flight toward the border of the Solar System gives us an expanding view of where we live and what our environment is. I believe it is going to become quite natural, in the years ahead, to think of ourselves as inhabitants of the Solar System, rather than just of Earth.

ASTEROID BELT

READ

We have also received some encouraging news about the radiation belt around Jupiter. The radiation there is much more intense than in the Van Allen Belts around the Earth. But the Jupiter radiation belt has a strange shape. It is like a thin disc, or a flattened out doughnut, with Jupiter in the doughnut's hole. This indicates it may be possible to send spacecraft quite close to Jupiter, relatively speaking, without passing through, or spending much time in, this deadly radiation belt. For scientific reasons, Pioneer 10 was sent through the heart of the radiation belt.

RAD BELT

- DISC

We have also found that Jupiter has a magnetic field 20 times as strong as Earth's, and that helium is an important element in Jupiter's make-up.

H - 20x

There is also encouraging news about the four large moons of Jupiter. By encouraging, I mean we may be able to land spacecraft on these moons some day, and it is possible that we may find life, or the precursors of life, there.

4 MOONS

LIFE ?

For example, the moon Io (which is larger than our own Moon) appears to have a density 3.5 times the density of water. This means it is more dense than our Moon, but not as dense as the Earth. It means that it has to be more than just a big chunk of ice. It appears to be made up of rocky materials. The other large moons of Jupiter, however, seem more like big chunks of ice.

~~Eo~~ Io not Ice

Moreover, Pioneer discovered that Io has an ionosphere, and thus also an atmosphere, but apparently a very thin one.

ATMOS

Io is a fast traveller. It completes a revolution around Jupiter in less than two Earth days. Astronomers noted years ago that it always appeared brighter for a while after emerging from Jupiter's shadow. Now it is believed that the ammonia gas in Io's atmosphere falls out as "snow" when Io is on the dark side of Jupiter. When Io comes back into the sunlight this ammonia "snow" glows brightly until it is warmed and returns to the atmosphere.

REVOL 2 DAYS SNOW-STORMS

These are just some of the strange things we are learning about the giant planet and its moons.

Planetary Theories

Learning more about all the planets, as we are now doing, does not immediately lead to simple and agreed upon explanations of how the Solar System was formed. We get the answer to one question and that just raises four or five new questions. But that is the way science works.

Jupiter is especially interesting to us because it is so different from Mars and Venus and Earth. It is much more like the Sun than like Earth. It is made of Sun-like materials, not Earth-like materials. JUPITER LIKE SUN

In fact, it now appears that Jupiter is a sort of second Sun that never quite made it. Even so it radiates 2 1/2 times as much energy as it receives from the Sun.

Jupiter is huge. It has 11 times the diameter of the Earth, and almost 300 times the mass (or weight) of Earth. If Jupiter had been about three times as large in diameter as it is, it could indeed have become a second Sun, with atomic processes like those of our Sun. Then Jupiter would have appeared brighter to us than our Moon, but not nearly so bright as the Sun, because of its smaller size and much greater distance from Earth. Two-star solar systems are not uncommon elsewhere in the universe. It would have been interesting to have had two Suns here in our own Solar System. It's too bad Jupiter didn't make it. 2 STAR SYSTEMS

Speculation has also increased on why Jupiter is so different from Earth, Mars, and Venus. One theory which has been advanced is that Jupiter and the other Outer Planets are the "normal" ones, so to speak, and Earth, Mars, and Venus the "funny" ones. In other words, Jupiter and the other Outer Planets were formed from the same material as the Sun, but Earth, Mars, and Venus are leftovers from some other star that exploded eons ago. According to this theory, we don't even belong to the Sun, except by adoption. We are foreigners as far as our Sun is concerned.

JUPITER, ETC. NORMAL

An opposing theory is that all the planets really do belong to our Sun. When the Solar System was formed, the planets made of heavier materials, like Earth, Mars, and Venus, were formed close to the Sun. Those made chiefly of the very light elements, hydrogen and helium, were formed much further out in the Solar System and became the Outer Planets.

OTHER THEORY

I am over-simplifying these theories, of course, but you can see that exploration of the planets does bring up interesting and fundamental questions for the mind of modern man to grapple with.

Outer Planets: Pioneer 11

We have a sister ship of Pioneer 10 on the way to Jupiter now. This is Pioneer 11, which has been underway since April 6 of last year and will pass Jupiter on December 5 of this year.

We have an interesting option in case of Pioneer 11. If we decide we can safely send it much closer to Jupiter than Pioneer 10 went, then it can pick up extra momentum and head off at the right speed and in the right direction to pass fairly close to Saturn in 1979. This is a decision we are still working on. P10. 11 SATURN 4 YRS.

Outer Planets: Mariner Jupiter/Saturn 1977

Our next spacecraft to visit the Outer Planets, after Pioneer 10 and 11, will be two larger Mariner-type craft, which will be launched toward both Jupiter and Saturn in 1977. These Mariner spacecraft will weigh about 1650 pounds each, compared with only 570 pounds for Pioneers 10 and 11. MJS '77

They will pass at a considerable distance from Jupiter (more than 200,000 miles) but will come within about 72,000 miles of Saturn. An especial effort will be made to learn more about Saturn's rings and about the moons of Saturn, including the big one named Titan, which appears to be one of the most interesting bodies in the Solar System. At least it appears to have a substantial atmosphere and atmospheric temperatures which might make it what has been called "a place to study prebiological organic evolution".

RINGS,

TITAN

Our two Mariner spacecraft will have to travel through space for 3 1/2 years before they pass Saturn. Since they are scheduled for launch in 1977, that means they reach Saturn in 1980 and 1981.

Planetary exploration takes patience. It cannot all be done in one big push, like the Apollo program to land on the Moon. We have to move step by step, decade by decade. But even so, a great deal will be learned, and many exciting voyages will be made, during the lifetimes of you young people here today.

PATIENCE

Inner Planets -- Venus and Mercury

Now let's come back from the Outer Planets and take a look at the Mariner 10 spacecraft we have headed in the other direction, in toward the innermost planet, Mercury.

Mariner 10 weighs about 1,100 pounds, or twice as much as Pioneer 10.

Mariner 10 passed Venus two weeks ago (on February 5) and used the gravity pull of that planet to send it on toward Mercury. It is the first spacecraft to use this kind of gravity-assist and also the first to head for Mercury.

MARIN. 10

Mariner 10 will pass Mercury on March 29.

Hg

Mariner 10 took about 3,400 pictures of cloud-covered Venus.

3400 - Venus

These pictures reveal for the first time something of the nature of the weather on Venus. They reveal a system of bands and streaks in the clouds roughly parallel to the planet's equator, and vaguely reminiscent of Jupiter's cloud bands.

UV pictures

Analysis of the masses of scientific data on Venus sent back by Mariner 10 have just begun.

Inner Planets -- Pioneer Venus 1978

Our new Budget, which the President announced earlier this month, calls for two new Pioneer spacecraft to be sent to Venus in 1978. These Pioneers will weigh about 1,500 pounds. PV '78

One will send entry probes into the Venus atmosphere at four different locations to measure its composition and global dynamics. These probes will be designed to survive until they reach the surface, but not necessarily on the surface. The second spacecraft will orbit Venus to study the characteristics of the atmosphere and their temporal changes.

This is a project which has had a top scientific priority as the next new step in planetary exploration. Detailed study of the composition and global dynamics of the atmosphere of Venus, which is 100 times denser than the Earth is, will give a better understanding both of Venus and of the forces that drive the Earth's atmosphere, meteorology, and climatology.

The Pioneer Venus missions still have to be approved by Congress.

Mars -- Viking 1975

Now let us turn to what I think will be our most exciting and most significant planetary missions in this decade.

These are two flights by large advanced Viking spacecraft to orbit and land on Mars. They will be launched next year and land in 1976.

The Viking spacecraft weigh 8,100 pounds.

VIKING

Each Viking consists of two major parts -- an Orbiter and a Lander. While the Orbiters relay communications with Earth and gather other data, the Landers will touch down softly on the Martian surface, transmit TV pictures, and deploy instruments to search for evidence of extraterrestrial life.

It just so happens that the celestial mechanics involved, and the scheduling dictated by budgetary considerations, will permit one of the Vikings to land on Mars on or about the Fourth of July 1976, on the 200th anniversary of American independence.

We hope our Viking landers will be the first to discover uncontestable evidence of life elsewhere in the Solar System. But this honor may go to the Russians.

As you probably know, the favorable opportunities to send spacecraft to Mars come at about two-year intervals. We passed up the opportunity to launch spacecraft to Mars in 1973, but the Russians did not.

The Russians launched two spacecraft to Mars in July of 1973 and two in August.

USSR

They call them Mars 4, 5, 6, and 7.

Mars 4 had bad luck. Because a braking rocket failed to function, Mars 4 sailed right on past the planet at an altutude of about 1,400 miles.

4, 5

Mars 5 has gone into orbit around the planet. (It is in an elliptical orbit with high and low points of about 20,000 miles and about 1,000 miles.)

Mars 6 and 7 will arrive at the planet early in March.

6, 7

The Russians have announced that Mars 4 and 5 are "analogous" and that 6 and 7 are "analogous". They have not announced which of the spacecraft will send down landers. One guess is that Mars 6 and 7 will attempt landings.

We don't know exactly what instruments the Russians are going to land on Mars. They will undoubtedly have imaging equipment to send back pictures. It is very unlikely that they will have life detection equipment such as we expect to land on Mars in 1976.

No Life Eqpt.

Unless there are life forms on Mars big enough to be seen in the Russian TV pictures, it is unlikely that we will know before 1976 whether there is life there or not.

However, if the Russians are successful on their current missions, they should be able to obtain the first detailed pictures of what the surface of Mars looks like.

From our Mariner 9 pictures, which were taken from Mars orbit, we know only the gross features: the canyons, the river beds, the polar ice caps, the volcanos, and features of that sort. We don't know how big the rocks are, we don't know if there are any strange geological formations, and of course we don't know if there are any sizeable life specimens. ? But these are the things we may learn from the Russian images if they are successful.

Life Specimens?

Our Viking Landers in 1976 will carry very high resolution cameras plus good biological detecting systems, so we will be able to tell whether there is any living material in the soil near the spacecraft, and also whether there has been any living material in the recent past.

Moreover, we will be landing in regions of Mars which are much more likely to support life than the regions the Russians have chosen to land in this year. The Russians have chosen the landing places that appear most interesting geologically, but less interesting biologically. U.S. vs USSR

We will be landing, for example, in the northern part of Mars (45° N) about 20 degrees from the edge of the north polar cap. We think there is water ice in the polar caps of Mars and we would expect to find the life forms where the water is, or has been. That is, of course, if the life forms on Mars are the same as we know on Earth. ICE CAPS

Our other landing will be at the mouth of what appear to have been river beds, in the expectation that water flowing in the past may have deposited elemental organisms of one kind or another in the soil at this point. RIVER BEDS

Tentative Mars Missions

We have no approved Mars missions beyond the Viking landings in 1976. But according to tentative plans (as set forth in the 1973 NASA Payload Model) we may

-- launch another Viking to Mars in 1979, 2ND VIKING

-- two new spacecraft to bring back surface samples from Mars in 1984, SAMPLE RETURN

-- and two similar spacecraft to bring back samples from the two moons of Mars, Phobos and Deimos, in 1990 and 1991. SAMPLES FROM PHOBOS + DEIMOS

In case you are wondering, we have no plans at this time for a manned landing on Mars. NO MANNED

I hope I have already made clear one reason why we don't have such plans. There are so many preliminary missions of great scientific importance to be undertaken first with automated (unmanned) spacecraft. These will keep us busy until the 1990s, at least. A second reason is the high cost. I will come back to this subject later on.

(1) NEED PRELIM MISS
(2) COST.

Other Tentative Missions to Explore the Solar System

I would like to tell you very briefly about some of the other tentative plans we have for exploring the planets in the 1980s and early 1990s.

We have tentative plans to send as many as 10 Mariner or Pioneer spacecraft to the Outer Planets in the 1980s. We will explore all the Outer Planets except Pluto, which is too far away.

10 MARIN, (All except Pluto)

About 1990 we may send two very heavy payloads weighing about 11 tons each to land a TV camera and other instruments on one of the moons of Jupiter.

LAND ON JUPITER MOON

In the mid-Eighties we may send two spacecraft to float in the heavy atmosphere of Venus at various levels. And by 1989 we may land a TV camera and other instruments on Venus.

FLOAT IN VENUS

We also have tentative plans to send eight automated spacecraft to the Moon between 1979 and 1991. These include Lunar Rovers which could travel 60 miles or more during a year on the Moon and others which could send samples back to Earth from the hidden side of the Moon.

8 to MOON

We also are considering sending automated spacecraft to study comets at close range, beginning in 1979, and perhaps make a landing on the nucleus of a comet. We also want to send automated spacecraft to visit one or more large asteroids in the mid-Eighties.

COMETS

ASTEROID

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The Search for Extraterrestrial Life

To conclude my description of NASA's plans, and hopes, for exploring the Solar System, I would like to go a little deeper into one of the great scientific and philosophical undertakings of our time: the quest for extraterrestrial life.

I imagine this is the part of the space program which many of you find most interesting.

Personal Views

I will give you some personal views:

1. There is no hope of finding intelligent life elsewhere in our Solar System. As far as this particular corner of the universe is concerned, we are it.

NO Intell. in SOLAL SYST.

2. I do think the chances are fair that we will find primitive life forms on Mars or other planets,
   or in their atmospheres,
   or on their moons.

FAIR for PRIMIT.

The Search for Extraterrestrial Life

Personal Views (continued)

3. Such a discovery will shed light on how life arose on Earth. It will strengthen our conviction that intelligent life must exist on the planets of millions, or even billions, of other stars in the universe.

Key question based on DNA? If so maybe it was planted there!

4. Will we ever be able to visit other civilizations in space, or expect them to visit Earth?

VISIT OTHERS?

I doubt it, in view of the great distances involved. We simply do not know how to begin to build the kind of spaceship that would be needed to reach even the nearest stars.

Maybe future generations of Earth men will learn how to build such interstellar space ships.

But first they will have to gain sweeping new insights into the physical laws of the universe. If there are such interstellar spaceships in use elsewhere in the universe, future generations of Earth men may hear about them on the intergalactic radio network, and save themselves a lot of time and trouble.

MAY HEAR ABOUT THEM

Personal Views (continued)

5. Although I am pessimistic about the chances of our travelling outside the Solar System, I believe the chances are very good that we can communicate by radio with advanced civilizations in our Milky Way Galaxy or in the many billions of other galaxies in the Universe.

COMMUN. GOOD.

I find it quite easy to believe that there must be many advanced civilizations broadcasting in our direction -- not to us specifically, but in our direction.

I am also sure that we have the technology needed -- right now -- to seriously search for and eventually intercept such signals.

The Search for Extraterrestrial Life

Personal Views (continued)

My optimism is based on a serious study made recently with support from NASA. It is called Project Cyclops. It gives very explicit directions for setting up an intergalactic listening system, with present day technology.

It is simply a question of money, and therefore of public interest.

Such a listening system will probably be set up by today's college students, when you are planning the programs and the budgets of the United States.

It's something to think about. But for the present, we at NASA are already deeply committed

FOR PRESENT

a) to exploring here at home in the Solar System

EXPLORE SOLAR

b) and to making more effective use of Earth orbit for science and practical benefits.

USE ORBIT

Questions

Now I would like to come back to the questions I usually get asked:

When will Americans return to the Moon?

When will we land men on Mars?

When will we establish a Large Space Station in Earth orbit?

Man's Return to the Moon

It is quite possible that the Russians will send men to the Moon for short stays during this decade, as we have already done in the Apollo program.

USSR this decade?

Whether we will want to send men back to the Moon on short Apollo-type missions requires further study. It is probably better to wait until we are ready to begin establishment of manned scientific bases for long term use, like our present bases in the Antarctic.

BASES LIKE ANTARCTIC

As I see it now, such bases on the Moon are not likely, even after 1991, unless they are built in international projects with the cooperation of the Soviet Union, the United States, and perhaps even Europe. Such bases would be too expensive for one country alone.

INT'L.

Prospects for Manned Mars Landing

I think manned exploration of Mars should be undertaken after we have had experience with large Space Stations in Earth orbit and with long stays in scientific bases on the Moon.

AFTER SPACE STATIONS

Like scientific bases on the Moon, manned expeditions to Mars will have to be organized on an international basis. They will be too expensive for any one country alone.

Prospects for a Large Manned Space Station

Skylab has clearly shown the potential value of the Space Shuttle and the Spacelab module, which can serve as a small space station accommodating about four scientists for missions up to 30 days.

USSR CERTAIN

But Skylab has also convinced us that we will need Large Space Stations for long missions employing larger and more sophisticated instruments.

U.S. MAYBE

But we simply do not have the funds in this decade to develop both the Space Shuttle and a Large Space Station. Faced with that choice, we had to give priority to the Shuttle and the smaller Spacelab module.

It is very likely that the Soviet Union will develop a space station, and they may have it in orbit by the end of this decade. How it will compare in size and versatility and productivity with the manned Spacelab module the Europeans are developing for use with the Space Shuttle remains to be seen.

Conclusion

We should not be dismayed by the fact that cost factors require international cooperation on such large undertakings as scientific bases on the Moon and manned landings on Mars. We should welcome it.

COOP. GOOD

I think such cooperation is an excellent way of helping to assure that we will enter the 21st century as a world at peace.

Will such long-term, large-scale international ventures in space be politically feasible one or two decades from now? I very much hope so. No one can say with certainty, of course. But I can point out that we have taken two important steps in this general direction already:

POLITICALLY FEASIBLE?

1) The scheduling of the Apollo/Soyuz Test Project for 1975 and

2) The agreement with nine European countries to develop the manned Spacelab module for use with the Space Shuttle.

READ

And by 1991 I anticipate that it will be clear to all that if it is desired to proceed on the major space missions of the future, there is no alternative to international cooperation -- no alternative that is both feasible and appropriate in a world at peace.

It is, of course, difficult to plan now for the future beyond 1991. Our Payload Model goes about as far as one can go.

For the near future -- for the next 18 years -- we do have well planned space programs and possibilities which we can afford on a national basis, which do encourage international cooperation in space on a growing scale, and which are the logical next steps to explore and use space.

The many space achievements we have tentatively planned for the next 18 years will enrich our lives, advance our technology, and enhance our security. They will be achievements that we as a people can be very proud of. READ

Dr. Fletcher, Associated Students Utah State University Lecture Series
February 20, 1974

EXPLORING THE SOLAR SYSTEM -- 1974 THRU 1991

We use to cut boring exp. of [illegible]
Use 1-15, 17-23, 32 [illegible] 37-42 [illegible]

and

THE SEARCH FOR EXTRATERRESTRIAL LIFE

Introduction

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Three. During the remainder of this decade we will concentrate much of our effort on developing the Space Shuttle transportation system, which is a better and cheaper way of getting manned and automated payloads to Earth orbit and back. We will also be working closely with a group of nine European countries which is developing a manned Spacelab module to be carried to orbit and back in the Space Shuttle.

Four. In addition to developing the Space Shuttle in this decade, we are planning and developing the improved payloads for the Shuttle to launch and service in the 1980s and 1990s. These payloads will include large automated observatories and a wide range of experiments and practical tasks to be performed in the manned Spacelab module.

Five. NASA has a strong program in aeronautical research to help meet national needs in this important field. Our main responsibility is to help identify and meet the research needs of civil aviation, but we also work closely with the military services.

Six. We also have a number of programs to demonstrate how new technology developed in the space program can be used to meet national needs outside the aerospace field. For example, we already know a great deal about how solar energy can be harnessed or how hydrogen can be used as a fuel.

For a number of reasons

~~Of these six main areas of NASA activity,~~ I have chosen to concentrate today on the ~~first one:~~ exploring throughout the Solar System and the search for extraterrestrial life.

There are three reasons for my choice:

First, ~~1)~~ I have found these are subjects of especial interest to university audiences.

Second, ~~2)~~ Our efforts to explore the planets and study comets are producing interesting results at the present time.

Third, ~~3)~~ We need broader public understanding of the reasons for exploring the planets, and Universities are certainly one of the key places in our society where this understanding should be generated.

Outer Planets: Pioneer 10

Let's start with the Outer Planets, and the remarkable voyage of Pioneer 10.

Pioneer 10 has travelled farther from the Earth and flown faster than any other man-made object. Its speed at launch had to be more than 32,000 miles per hour. That is why we were already 15 years into the Space Age before the first voyage to the Outer Planets was attempted.

Significant advances had to be made in spacecraft and rocket technology and space communications before a spacecraft like Pioneer 10 could be launched.

For example, it flies so far from the Sun that it cannot rely on the solar cells used to provide electrical power for other spacecraft. It is the first NASA spacecraft to rely solely on nuclear energy for the electrical power needed for its communications equipment and other instruments.

This small spacecraft, weighing only 570 pounds, passed Jupiter exactly on target, with all instruments working, after a voyage of 641 days and more than 500 million miles.

It not only passed Jupiter on target, its arrival was so precisely timed, within a minute or two, that it passed behind one of the moons of Jupiter -- the moon Io -- for important occultation observations.

Moreover, Pioneer 10 sailed through the intense radiation zones of Jupiter without significant damage. The radiation was stronger than expected, Pioneer's margin of survival was apparently small, but it came through with flying colors.

The gravity of Jupiter increased Pioneer's speed to 82,000 miles per hour. This speed will permit it to escape the Sun's gravity and sail on through interplanetary space until it is captured by the gravity of some distant star.

Pioneer 10 is still reporting on the interplanetary environment. We expect to keep in touch with it until it passes the orbit of Uranus some time in 1979. By then it will be nearly two billion miles from Earth.

Sending radio commands to Pioneer and getting back color images of Jupiter and data from the 10 other major scientific instruments aboard has been a tremendous communications achievement.

Keep in mind that Pioneer's antenna must always be pointed toward Earth for successful communications.

Keep in mind that Jupiter's radio transmitter draws only eight watts of power to begin with, and that these signals are weakened to only a tiny fraction of a watt by the time they reach Earth. [For the engineers in the audience, this tiny fraction of a watt is $10^{-\cancel{15}\,12}$ or less. That's one quadrillionth or less.]

Keep in mind that these infinitessimal signals must be picked up by one of NASA's three big-dish antennas in California, Spain, or Australia, separated from all the radio noise of space, and amplified to readable strength.

Then consider that some of these signals, when enhanced through a special computer process at the University of Arizona, have produced color images of Jupiter with significantly more detail than can be seen through the best telescopes on Earth, and you will see why I consider Pioneer 10 one of the most remarkable creations of the Space Age.

What have we learned from Pioneer 10?

Articles are beginning to appear in the scholarly journals. The magazine Science for January 25 had a good preliminary round-up of results. Further disclosures will be made at a comprehensive press briefing at NASA Headquarters in April.

When all the results are in, we are going to know a great deal more about Jupiter and its moons than we did before, and it is likely we will also know much more about how Jupiter and the other planets of the Solar System were formed.

One of the first important findings of Pioneer 10 has been that the Asteroid Belt is not a significant hazard to navigation. Despite some early fears on this subject, we are definitely not walled in from the Outer Planets. This finding and Pioneer's continued flight toward the border of the Solar System gives us an expanding view of where we live and what our environment is. I believe it is going to become quite natural, in the years ahead, to think of ourselves as inhabitants of the Solar System, rather than just of Earth.

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We have also received some encouraging news about the radiation belt around Jupiter. The radiation there is much more intense than in the Van Allen Belts around the Earth. But the Jupiter radiation belt has a strange shape. It is like a thin disc, or a flattened out doughnut, with Jupiter in the doughnut's hole. This indicates it may be possible to send spacecraft quite close to Jupiter, relatively speaking, without passing through, or spending much time, in this deadly radiation belt. For scientific reasons, Pioneer 10 was sent through the heart of the radiation belt.

We have also found that Jupiter has a magnetic field 20 times as strong as Earth's, and that helium is an important element in Jupiter's make-up.

There is also encouraging news about the four large moons of Jupiter. By encouraging, I mean we may be able to land spacecraft on these moons some day, and it is possible that we may find life, or the precursors of life, there.

For example, the moon Io (which is larger than our own Moon) appears to have a density 3.5 times the density of water. This means it is more dense than our Moon, but not as dense as the Earth. It means that it has to be more than just a big chunk of ice. It appears to be made up of rocky materials. The other large moons of Jupiter, however, seem more like big chunks of ice.

Moreover, Pioneer discovered that Io has an ionosphere, and thus also an atmosphere, but apparently a very thin one.

Io is a fast traveller. It completes a revolution around Jupiter in less than two Earth days. Astronomers noted years ago that it always appeared brighter for a while after emerging from Jupiter's shadow. Now it is believed that the ammonia gas in Io's atmosphere falls out as "snow" when Io is on the dark side of Jupiter. When Io comes back into the sunlight this ammonia "snow" glows brightly until it is warmed and returns to the atmosphere.

These are just some of the strange things we are learning about the giant planet and its moons.

Planetary Theories

Learning more about all the planets, as we are now doing, does not immediately lead to simple and agreed upon explanations of how the Solar System was formed. We get the answer to one question and that just raises four or five new questions. But that is the way science works.

Jupiter is especially interesting to us because it is so different from Mars and Venus and Earth. It is much more like the Sun than like Earth. It is made of Sun-like materials, not Earth-like materials.

In fact, it now appears that Jupiter is a sort of second Sun that never quite made it. Even so it radiates 2 1/2 times as much energy as it receives from the Sun.

Jupiter is huge. It has 11 times the diameter of the Earth, and almost 300 times the mass (or weight) of Earth. If Jupiter had been about three times as large in diameter as it is, it could indeed have become a second Sun, with atomic processes like those of our Sun, and all that. Then Jupiter would have appeared brighter to us than our Moon, but not nearly so bright as the Sun, because of its smaller size and much greater distance from Earth. Two-star solar systems are not uncommon elsewhere in the universe. It would have been interesting to have had two Suns here in our own Solar System. It's too bad Jupiter didn't make it.

Speculation has also increased on why Jupiter is so different from Earth, Mars, and Venus. One theory which has been advanced is that Jupiter and the other Outer Planets are the "normal" ones, so to speak, and Earth, Mars, and Venus the "funny" ones. In other words, Jupiter and the other Outer Planets were formed from the same material as the Sun, but Earth, Mars, and Venus are leftovers from some other star that exploded eons ago. According to this theory, we don't even belong to the Sun, except by adoption. We are foreigners as far as our Sun is concerned.

An opposing theory is that all the planets really do belong to our Sun. When the Solar System was formed, the planets made of heavier materials, like Earth, Mars, and Venus, were formed close to the Sun. Those made chiefly of the very light elements, hydrogen and helium, were formed much further out in the Solar System and became the Outer Planets.

I am over-simplifying these theories, of course, but you can see that exploration of the planets does bring up interesting and fundamental questions for the mind of modern man to grapple with.

Outer Planets: Pioneer 11

We have a sister ship of Pioneer 10 on the way to Jupiter now. This is Pioneer 11, which has been underway since April 6 of last year and will pass Jupiter on December 5 of this year.

We have an interesting option in case of Pioneer 11. If we decide we can safely send it much closer to Jupiter than Pioneer 10 went, then it can pick up extra momentum and head off at the right speed and in the right direction to pass fairly close to Saturn in 1979. This is a decision we are still working on.

Outer Planets: Mariner Jupiter/Saturn 1977

Our next spacecraft to visit the Outer Planets, after Pioneer 10 and 11, will be two larger Mariner-type craft, which will be launched toward both Jupiter and Saturn in 1977. These Mariner spacecraft will weigh about 1650 pounds each, compared with only 570 pounds for Pioneers 10 and 11. They will pass at a considerable distance from Jupiter (more than 200,000 miles) but will come within about 72,000 miles of Saturn. An especial effort will be made to learn more about Saturn's rings and about the moons of Saturn, including the big one named Titan, which appears to be one of the most interesting bodies in the Solar System. At least it appears to have a substantial atmosphere and atmospheric temperatures which might make it what has been called "a place to study prebiological organic evolution". These two Mariners will have to travel through space for 3 1/2 years before they pass Saturn. Since they are scheduled for launch in 1977, that means they will reach Saturn in 1980 and 1981.

Planetary exploration takes patience. It cannot all be done in one big push, like the Apollo program to land on the Moon. We have to move step by step, decade by decade. But even so, a great deal will be learned, and many exciting voyages will be made, during the lifetimes of you young people here today.

Outer Planets -- Tentative Plans

So far I have been talking about presently approved programs for exploring the Outer Planets. Now let's take a look at the tentative plans for exploring the Outer Planets through 1991 (according to the 1973 NASA Payload Model I mentioned earlier).

Continuing our present line of attack we might launch as many as 10 Mariner or Pioneer spacecraft to the Outer Planets in the 1980s, including flybys of Uranus and Neptune, probes into the atmospheres of Jupiter, Uranus, and Saturn, and orbiters around Jupiter and Saturn. And in 1990 and 1991 we might send two very heavy spacecraft weighing 21,000 pounds each to orbit one of Jupiter's moons at an altitude of only 55 miles, and land an instrument package, including a TV camera, on this Jovian moon.

That takes us through 1991. Today's college students will be running the country by then, and you can make the decisions what to do next.

Inner Planets -- Venus and Mercury

Now let's come back from the Outer Planets and take a look at the Mariner 10 spacecraft we have headed in the other direction, in toward the innermost planet, Mercury.

Mariner 10 weighs about 1,100 pounds, or twice as much as Pioneer 10.

Mariner 10 passed Venus two weeks ago (on February 5) and used the gravity pull of that planet to send it on toward Mercury. It is the first spacecraft to use this kind of gravity-assist and also the first to head for Mercury.

(Note: Update with results of Venus encounter and prospects for Mercury encounter and return to Mercury after six months.)

Next page is 18 A

Inner Planets -- Pioneer Venus 1978

Our new Budget, which the President announced earlier this month, calls for two new Pioneer spacecraft to be sent to Venus in 1978. These Pioneers will weigh about 1,500 pounds.

One will send entry probes into the Venus atmosphere at four different locations to measure its composition and global dynamics. These probes will be designed to survive until they reach the surface, but not necessarily on the surface. The second spacecraft will orbit Venus to study the characteristics of the atmosphere and their temporal changes.

This is a project which has had a top scientific priority as the next new step in planetary exploration. Detailed study of the composition and global dynamics of the atmosphere of Venus, which is 100 times denser than the Earth is, will give a better understanding both of Venus and of the forces that drive the Earth's atmosphere, meteorology, and climatology.

The Pioneer Venus missions still have to be approved by Congress.

Next page is 18 B

Inner Planets -- Tentative Plans

According to tentative plans, by 1983 we may send two spacecraft to orbit Venus at a low altitude of 270 miles and map the surface by radar. By 1985 we may send two spacecraft to float in the Venus atmosphere at various levels, and by 1989 we may send a Large Lander to Venus to take TV cameras and other instruments to the surface. The feasibility of TV cameras is still uncertain. Any payloads to land on Venus will have to be very carefully designed, because the surface temperatures are on the order of 800 degrees Fahrenheit, or hot enough to melt lead.

Again according to tentative plans, we may return to Mercury in 1987 with two spacecraft which would orbit this Sun-scorched planet. One spacecraft would be in a circular orbit at 270 miles altitude, and the other would be in an elliptical orbit coming within 110 miles of the surface.

Mars -- Viking 1975

Now let us turn to what I think will be our most exciting and most significant planetary missions in this decade.

These are two flights by large advanced Viking spacecraft to orbit and land on Mars. They will be launched next year and land in 1976.

The Viking spacecraft weigh 8,100 pounds.

Each Viking consists of two major parts -- an Orbiter and a Lander. While the Orbiters relay communications with Earth and gather other data, the Landers will touch down softly on the Martian surface, transmit TV pictures, and deploy instruments to search for evidence of extraterrestrial life.

It just so happens that the celestial mechanics involved, and the scheduling dictated by budgetary considerations, will permit one of the Vikings to land on Mars on or about the Fourth of July 1976, on the 200th anniversary of American independence.

We hope our Viking landers will be the first to discover uncontestable evidence of life elsewhere in the Solar System. But this honor may go to the Russians.

As you probably know, the favorable opportunities to send spacecraft to Mars come at about two-year intervals. We have passed up the opportunity to launch spacecraft to Mars this year, but the Russians have not. The Soviet Union now has four spacecraft enroute to Mars. They are due to arrive in February and early March.

(Note: update as necessary.)

We don't know exactly what instruments the Russians are going to land on Mars. They will undoubtedly have imaging equipment to send back pictures. It is very unlikely that they will have life detection equipment such as we expect to land on Mars in 1976.

Unless there are life forms on Mars big enough to be seen in the Russian TV pictures, it is unlikely that we will know before 1976 whether there is life there or not.

However, if the Russians are successful on their current missions, they should be able to obtain the first detailed pictures of what the surface of Mars looks like.

From our Mariner 9 pictures, which were taken from Mars orbit, we know only the gross features: the canyons, the river beds, the polar ice caps, the volcanos, and features of that sort. We don't know how big the rocks are, we don't know if there are any strange geological formations, and of course we don't know if there are any sizeable life specimens. But these are the things we may learn from the Russian images if they are successful.

Our Viking Landers in 1976 will carry very high resolution cameras plus good biological detecting systems, so we will be able to tell whether there is any living material in the soil near the spacecraft, and also whether there has been any living material in the recent past.

Moreover, we will be landing in regions of Mars which are much more likely to support life than the regions the Russians have chosen to land in this year. The Russians have chosen the landing places that appear most interesting geologically, but less interesting biologically.

We will be landing, for example, in the northern part of Mars (45° N) about 20 degrees from the edge of the north polar cap. We think there is water ice in the polar caps of Mars and we would expect to find the life forms where the water is, or has been. That is, of course, if the life forms on Mars are the same as we know on Earth.

Our other landing will be at the mouth of what appear to have been river beds, in the expectation that water flowing in the past may have deposited elemental organisms of one kind or another in the soil at this point.

Tentative Mars Missions

We have no approved Mars missions beyond the Viking landings in 1976. But according to tentative plans (as set forth in the 1973 NASA Payload Model) we may

-- launch another Viking to Mars in 1979,

-- two new spacecraft to bring back surface samples from Mars in 1984,

-- and two similar spacecraft to bring back samples from the two moons of Mars, Phobos and Deimos, in 1990 and 1991.

In case you are wondering, we have no plans at this time for a manned landing on Mars.

I hope I have already made clear one reason why we don't have such plans. There are so many preliminary missions of great scientific importance to be undertaken first with automated (unmanned) spacecraft. These will keep us busy until the 1990s, at least. A second reason is the high cost. I will come back to this subject later on.

Tentative Plans for Automated Moon Missions

We have no approved plans to send either manned or automated spacecraft back to the Moon.

However, in our tentative plans through 1991 we do consider sending eight automated spacecraft to the Moon.

These missions include:

-- a Lunar Polar Orbiter in 1979;

-- two other Lunar Orbiters in the 1980s;

-- two Lunar Rovers in the 1980s which would travel as far as 60 miles during a year on the Moon;

-- a so-called Lunar Halo Satellite which would assure communications with the hidden side of the Moon;

-- and finally, in 1990 and 1991, two Lunar Rovers which could return samples to Earth from any point on the Moon. To date, no samples have been returned from the hidden side of the Moon.

Some day we will surely want to consider the desirability of establishing one or more large manned scientific bases on the Moon, similar to our scientific bases in the Antarctic.

I will discuss this possibility in greater detail later on.

I should add here that hundreds of scientists in this country and abroad are still working on the lunar samples brought back in the Apollo program. It is estimated that it will take them more than 10 years to complete their studies.

We are also still getting back useful data from some of the automated experiments that each of the five Apollo crews placed on the Moon. The design life of these experiments was only one year, but some have been operating for more than four years.

These experiments have a nuclear power supply -- or to be more precise, radio isotope thermoelectric generators. (Pioneer 10 and 11 carry similar generators.)

The Importance of Investigating Comets

The scientific community gives high priority to sending unmanned spacecraft out to investigate comets at close range during the next two decades.

Since comets -- or certainly some comets -- come from outside the Solar System, they can give us valuable information about interstellar space, the vast regions between the stars. They can also help us understand how other stellar systems (like our Solar System) are formed. Since comets (and meteorites which may be derived from comets) have been found to contain organic molecules, they can also give us valuable clues as to how life may arise throughout the universe.

Until recently, we were not able to learn much about comets. Now, for the first time, we have the technology to send our instruments out where the comets are and study them at close range. That is why the idea of visiting comets, which may seem very strange to you, is an idea whose time has come.

Comet Kohoutek

Comet Kohoutek has been a very valuable source of information to astronomers. And it has served to stimulate public interest in comets and space exploration even though it was not bright enough to be seen by many people.

I won't have time today to go into what we learned about Comet Kohoutek, except to say that it appears to have come from outside the Solar System, from interstellar space. And it does appear to contain molecules and organic molecules that could be precursors of life forms.

Kohoutek is travelling in an orbit that will return it to the inner Solar System in about 75,000 years.

But of course we don't have to wait for it. There are other important comets that we can study at close range from spacecraft during the next two decades. Although most people don't know it, there are some comets, called short-period comets, which come around the Sun on schedule every few years.

Tentative Plans to Visit Comets

Now let us take a look at our tentative plans to visit some comets.

For example, it would be possible to launch a small spacecraft weighing about 1,000 pounds in 1976 to take advantage of the opportunity to fly through the tails of two well-known short-period comets (well known to astronomers, that is). It is a budgetary question whether we will be able to fly this mission.

In 1979 a spacecraft weighing 4,500 pounds could be sent to make a slow fly-by of the Comet Encke, coming within 2,700 miles of the comet's nucleus.

Comet Encke comes back around the Sun every 3.3 years, so that we can make a series of close-up investigations of increasing difficulty.

After the fly-by mission, a rendezvous mission will be considered. It would permit the spacecraft to enter the inner coma of Comet Encke and travel along with it. (The coma is a nebulous mass which surrounds the nucleus of the comet. The coma and nucleus together make up the head of the comet.) After the spacecraft has made a close-up study of the nucleus, a landing on the nucleus might be attempted.

The missions to Comet Encke are doubly important. They will yield valuable information, and they will help us prepare for the opportunity to make a fly-by close to the best known comet of them all, Halley's Comet, in 1985.

Halley's Comet comes back around the Sun about every 75 years. Each of its appearances has been recorded since the year 240 B.C. When it returns in 1985 we will have our first opportunity to examine it with a full complement of modern instruments on the ground and in space.

It is proposed to fly the Halley spacecraft within about 5,000 miles of the comet's nucleus.

Tentative Plans to Visit Asteroids

Asteroids are just as important to visit as the planets. In fact, they may tell us more about how the Solar System was formed, and how life began here, than the planets will.

The Asteroid Belt is made up of thousands of large and small chunks of solid material which orbit the Sun out beyond the orbit of Mars. Several asteroids are larger than Ireland, for example.

It is not known for certain whether asteroids are the remnants of a primitive planet that broke up, or whether they were the potential building blocks for a planet that never got it all together, as the saying goes. A third theory is that some asteroids may be the nuclei of ancient comets.

In any event, the scientific community gives a fairly high priority to exploring asteroids now that we have the technology to do so.

According to tentative plans, we could send two automated spacecraft to visit asteroids in 1986. They could send back TV pictures and other data from very close range -- from distances measured in feet rather than miles.

I assume that some day we will want to send scientists to land on asteroids. Such landings would be relatively easy to make because the gravity forces to be overcome on landing and take-off would not be great. But such landings are not in our tentative schedule for the next two decades.

The Helios Program

I want to tell you, too, about an important international cooperative effort to explore in the Solar System.

German scientists are building two sophisticated Helios spacecraft to be launched by NASA into solar orbit quite close to the Sun. By quite close I mean .3 of an astronomical unit, or about 28 million miles. That is much closer than any spacecraft has come before. It is much closer than the orbit of Mercury, which averages about 36 million miles from the Sun. Our Mariner 10 spacecraft now enroute to Mercury will remain outside the orbit of Mercury.

The first Helios spacecraft will be launched this year, the second in 1976. The Helios spacecraft weigh about 690 pounds each.

The scientific objects of the Helios program are not to study the Sun itself but to investigate the properties of, and the processes in, interplanetary space close to the Sun.

Seven of the 10 experiments aboard will be provided by German scientists and three by NASA in cooperation with American, Australian, and Italian scientists.

Helios is an excellent example of how the costs and benefits of space exploration can be shared on an international basis.

The Quest for Extraterrestrial Life

To conclude my description of NASA's plans, and hopes, for exploring the Solar System, I would like to go a little deeper into one of the great scientific and philosophical undertakings of our time: the quest for extraterrestrial life.

I imagine this is the part of the space program which many of you find most interesting.

Personal Views

I will give you some personal views:

1. There is no hope of finding intelligent life elsewhere in our Solar System. As far as this particular corner of the universe is concerned, we are it.
2. I do think the chances are fair that we will find primitive life forms on Mars or other planets,
   or in their atmospheres,
   or on their moons.
3. Such a ~~This~~ discovery will shed light on how life arose on Earth. It will strengthen our conviction that intelligent life must exist on the planets of millions, or even billions, of other stars in the universe.

The Search for Extraterrestrial Life

Personal Views (continued)

4. Will we ever be able to visit other civilizations in space, or expect them to visit Earth?

   I doubt it, in view of the great distances involved.

   We simply do not know how to begin to build the kind of spaceship that would be needed to reach even the nearest stars.

Maybe future generations of Earth men will learn how to build such interstellar space ships.

But first they will have to gain sweeping new insights into the physical laws of the universe. If there are such interstellar spaceships in use elsewhere in the universe, future generations of Earth men may hear about them on the intergalactic radio network, and save themselves a lot of time and trouble.

5. Although I am pessimistic about the chances of our travelling outside the Solar System, I believe the chances are very good that we can communicate by radio with advanced civilizations in our Milky Way Galaxy or in the many billions of other galaxies in the Universe.

   I find it quite easy to believe that there must be many advanced civilizations broadcasting in our direction -- not to us specifically, but in our direction.

The Search for Extraterrestrial Life

Personal Views (continued)

I am also sure that we have the technology needed -- right now -- to seriously search for and eventually intercept such signals.

My optimism is based on a serious study made recently with support from NASA. It is called Project Cyclops. It gives very explicit directions for setting up an intergalactic listening system, with present day technology.

It is simply a question of money, and therefore of public interest.

Such a listening system will probably be set up by today's college students, when you are planning the programs and the budgets of the United States.

It's something to think about. But for the present, we at NASA are already deeply committed

a) to exploring here at home in the Solar System

b) and to making more effective use of Earth orbit for science and practical benefits.

The Importance of Earth Orbit

Now I want to remind you, I have been talking about just one part of the NASA program -- the exploration of the Solar System.

A much bigger part of NASA's space work in the next two decades is going to be done closer to home, in Earth orbit.

Looking at our tentative plans thru 1991, we find an average of three payloads per year going to the Moon or planets, and 41 per year destined for Earth orbit.

That's a ratio of 14 to 1 in favor of Earth orbit.

If we had more time, I would like very much to describe for you the exciting and productive payloads we have planned for Earth orbit thru 1991.

I will describe just one, the Large Space Telescope, because it fits in with our programs to explore the Solar System. The LST will be used primarily to explore the Universe, and possibly to see beyond the edge of the Universe. But it will also be trained on the planets of our Solar System.

Large Space Telescope

The biggest telescopes we have on Earth today, such as the 200-inch telescope on Mount Palomar, can see about one billion light years into the Universe.

That is a very long distance. Almost beyond comprehension. When we look at anything that far away it is already a billion years older than what we see.

But the Large Space Telescope we plan to orbit in 1980 will enable us to see 10 times further or a distance of 10 billion light years.

If present estimates of the size of the Universe are correct, it does not extend out that far. So we will see beyond the edge of the Universe, where theoretically there is nothing.

Of course, if we do see something 10 billion light years away with the Large Space Telescope, then our present concepts of the Universe will have to be drastically revised.

The LST spacecraft will weigh about 11 tons. Its mirror will be 120 inches in diameter. That is smaller, of course, than the 200-inch mirror at Mount Palomar, but the LST will have the tremendous advantage of being above the Earth's atmosphere. Operating in zero gravity is also a significant advantage because it eliminates the distortions caused by the stresses and strains of gravity on Earth-based telescope structures and optics.

The LST will produce images and spectrographs of the planets, stars, nebulae, and galaxies. It will measure the structure of quasars and perhaps give us an understanding of how they produce such vast amounts of energy. By comparison with quasars, our Sun is quite puny. With all that we have learned about the atomic processes of the Sun, we still do not know how quasars work. Their energy producing processes are beyond our comprehension. Modern physics cannot explain them.

The LST will also study the state of interstellar and intergallactic matter -- the matter from which new star systems appear to be made. Indeed, with the LST we should be able to witness quite clearly the birth of stars, their evolution, and their death.

The LST will also look closely at the very dense neutron stars and the so-called Black Holes, which represent the ultimate collapse of stellar matter. In Black Holes, as you probably know, the gravity forces are so intense that even light cannot escape.

Our first LST will be orbited by the Space Shuttle in 1980, according to tentative plans. It will be revisited by Shuttle crews in 1981 and 1982, and brought back to Earth for refurbishing and re-launch in 1983.

Other astronomical payloads in Earth orbit in the 1980s will be High Energy Astronomical Observatories, Large Solar Observatories, Large Radio Astronomy Observatories, and Focusing X-Ray Telescopes.

These large spacecraft, unmanned but serviced by the Space Shuttle, should enable us to make unprecedented gains in understanding the Universe over the next two decades.

I think it very important that universities be able to tell this story in dramatic fashion to their students and other citizens as the story unfolds. The LST will truly make the next decade a new Age of Discovery.

Shorter Version

Dr. Fletcher, Associated Students Utah State University Lecture Series
Utah State University, Logan, Utah
February 20, 1974

EXPLORING THE SOLAR SYSTEM -- 1974 THRU 1991

and

THE SEARCH FOR EXTRATERRESTRIAL LIFE

Introduction

The National Aeronautics and Space Administration has a strong, realistic, and highly rewarding national space effort planned for this decade and the next.

Our current programs are working out very well. We have had some notable successes. Here are some examples:

-- Skylab, America's first space station and Man's first home in space, has been an outstanding achievement.

-- Pioneer 10 stirred the imaginations of millions of people around the world as it passed close to the giant planet Jupiter in December.

-- Mariner 10 has passed Venus and will fly by the innermost planet Mercury on March 29.

-- Our most ambitious scientific satellite to date, the Orbiting Astronomical Observatory named for Copernicus (OAO-3) has produced evidence of the existence of a Black Hole here in our own Milky Way Galaxy.

-- Our first Earth Resources Technology Satellite, ERTS-1, has proved to be a valuable new tool to help manage the world's resources and protect the environment.

-- The worldwide effort to study Comet Kohoutek, which NASA helped to coordinate, has produced valuable results and stirred public interest in comets, even if Kohoutek was not seen by very many people.

These current achievements give you some idea of the broad range of NASA's activities today -- activities which range through the spectrum of modern scientific endeavor, from measuring the drifting apart of the continents at about one inch per year to searching for life elsewhere in the solar system.

1973 NASA Payload Model

We have recently completed an important new planning exercise at NASA. We have drawn up a document we call the 1973 NASA Payload Model which shows with some precision the number of payloads, and the kinds of payloads, we might reasonably expect to send to Earth orbit and farther out into the solar system each year from now through 1991.

Our planning that far ahead is still quite tentative, as it should be, but I can still give you a good idea of the shape of the future in space through 1991. And we have been quite realistic about the cost, because the NASA payload model I am talking about assumes a level of expenditures at about the current level -- that is, around $3.2 or $3.3 billion dollars per year, adjusted as necessary for inflation.

Six Major Areas of NASA Activity

To help organize my remarks today, I would like to identify six major areas of NASA activity. We won't have time to discuss them all, but I do want you to know about each of them.

One. We will continue to explore throughout the Solar System with automated spacecraft (that is, unmanned spacecraft); and one of the main aims of this exploration will be to find evidence of extraterrestrial life, or at least a better understanding of how life arose on Earth.

Two. We will intensify our use of spacecraft in Earth orbit. Some of these spacecraft will look back at Earth and some will study the Sun or look far out into the Universe. Some will seek scientific information, some will produce practical benefits.

Three. During the remainder of this decade we will concentrate much of our effort on developing the Space Shuttle transportation system, which is a better and cheaper way of getting manned and automated payloads to Earth orbit and back. We will also be working closely with a group of nine European countries which is developing a manned Spacelab module to be carried to orbit and back in the Space Shuttle.

Four. In addition to developing the Space Shuttle in this decade, we are planning and developing the improved payloads for the Shuttle to launch and service in the 1980s and 1990s. These payloads will include large automated observatories and a wide range of experiments and practical tasks to be performed in the manned Spacelab module.

Five. NASA has a strong program in aeronautical research to help meet national needs in this important field. Our main responsibility is to help identify and meet the research needs of civil aviation, but we also work closely with the military services.

Six. We also have a number of programs to demonstrate how new technology developed in the space program can be used to meet national needs outside the aerospace field. For example, we already know a great deal about how solar energy can be harnessed or how hydrogen can be used as a fuel.

For a number of reasons, I have chosen to concentrate today on exploring throughout the Solar System and the search for extraterrestrial life.

First. I have found these are subjects of especial interest to university audiences.

Second. Our efforts to explore the planets and study comets are producing interesting results at the present time.

Third. We need broader public understanding of the reasons for exploring the planets, and universities are certainly one of the key places in our society where this understanding should be generated.

Outer Planets: Pioneer 10

Let's start with the Outer Planets, and the remarkable voyage of Pioneer 10.

Pioneer 10 has travelled farther from the Earth and flown faster than any other man-made object. Its speed at launch had to be more than 32,000 miles per hour. That is why we were already 15 years into the Space Age before the first voyage to the Outer Planets was attempted.

Significant advances had to be made in spacecraft and rocket technology and space communications before a spacecraft like Pioneer 10 could be launched.

For example, it flies so far from the Sun that it cannot rely on the solar cells used to provide electrical power for other spacecraft. It is the first NASA spacecraft to rely solely on nuclear energy for the electrical power needed for its communications equipment and other instruments.

This small spacecraft, weighing only 570 pounds, passed Jupiter exactly on target, with all instruments working, after a voyage of 641 days and more than 500 million miles.

It not only passed Jupiter on target, its arrival was so precisely timed, within a minute or two, that it passed behind one of the moons of Jupiter -- the moon Io -- for important occultation observations.

Moreover, Pioneer 10 sailed through the intense radiation zones of Jupiter without significant damage. The radiation was stronger than expected, Pioneer's margin of survival was apparently small, but it came through with flying colors.

The gravity of Jupiter increased Pioneer's speed to 82,000 miles per hour. This speed will permit it to escape the Sun's gravity and sail on through interplanetary space until it is captured by the gravity of some distant star.

Pioneer 10 is still reporting on the interplanetary environment. We expect to keep in touch with it until it passes the orbit of Uranus some time in 1979. By then it will be nearly two billion miles from Earth.

Sending radio commands to Pioneer and getting back color images of Jupiter and data from the 10 other major scientific instruments aboard has been a tremendous communications achievement.

Keep in mind that Pioneer's antenna must always be pointed toward Earth for successful communications.

Keep in mind that Jupiter's radio transmitter draws only eight watts of power to begin with, and that these signals are weakened to only a tiny fraction of a watt by the time they reach Earth. [For the engineers in the audience, this tiny fraction of a watt is 10^{-12} or less. That's one quadrillionth or less.]

Keep in mind that these infinitesimal signals must be picked up by one of NASA's three big-dish antennas in California, Spain, or Australia, separated from all the radio noise of space, and amplified to readable strength.

Then consider that some of these signals, when enhanced through a special computer process at the University of Arizona, have produced color images of Jupiter with significantly more detail than can be seen through the best telescopes on Earth, and you will see why I consider Pioneer 10 one of the most remarkable creations of the Space Age.

What have we learned from Pioneer 10?

Articles are beginning to appear in the scholarly journals. The magazine Science for January 25 had a good preliminary round-up of results. Further disclosures will be made at a comprehensive press briefing at NASA Headquarters in April.

When all the results are in, we are going to know a great deal more about Jupiter and its moons than we did before, and it is likely we will also know much more about how Jupiter and the other planets of the Solar System were formed.

One of the first important findings of Pioneer 10 has been that the Asteroid Belt is not a significant hazard to navigation. Despite some early fears on this subject, we are definitely not walled in from the Outer Planets. This finding and Pioneer's continued flight toward the border of the Solar System gives us an expanding view of where we live and what our environment is. I believe it is going to become quite natural, in the years ahead, to think of ourselves as inhabitants of the Solar System, rather than just of Earth.

We have also received some encouraging news about the radiation belt around Jupiter. The radiation there is much more intense than in the Van Allen Belts around the Earth. But the Jupiter radiation belt has a strange shape. It is like a thin disc, or a flattened out-doughnut, with Jupiter in the doughnut's hole. This indicates it may be possible to send spacecraft quite close to Jupiter, relatively speaking, without passing through, or spending much time in, this deadly radiation belt. For scientific reasons, Pioneer 10 was sent through the heart of the radiation belt.

We have also found that Jupiter has a magnetic field 20 times as strong as Earth's, and that helium is an important element in Jupiter's make-up.

There is also encouraging news about the four large moons of Jupiter. By encouraging, I mean we may be able to land spacecraft on these moons some day, and it is possible that we may find life, or the precursors of life, there.

For example, the moon Io (which is larger than our own Moon) appears to have a density 3.5 times the density of water. This means it is more dense than our Moon, but not as dense as the Earth. It means that it has to be more than just a big chunk of ice. It appears to be made up of rocky materials. The other large moons of Jupiter, however, seem more like big chunks of ice.

Moreover, Pioneer discovered that Io has an ionosphere, and thus also an atmosphere, but apparently a very thin one.

Io is a fast traveller. It completes a revolution around Jupiter in less than two Earth days. Astronomers noted years ago that it always appeared brighter for a while after emerging from Jupiter's shadow. Now it is believed that the ammonia gas in Io's atmosphere falls out as "snow" when Io is on the dark side of Jupiter. When Io comes back into the sunlight this ammonia "snow" glows brightly until it is warmed and returns to the atmosphere.

These are just some of the strange things we are learning about the giant planet and its moons.

Planetary Theories

Learning more about all the planets, as we are now doing, does not immediately lead to simple and agreed upon explanations of how the Solar System was formed. We get the answer to one question and that just raises four or five new questions. But that is the way science works.

Jupiter is especially interesting to us because it is so different from Mars and Venus and Earth. It is much more like the Sun than like Earth. It is made of Sun-like materials, not Earth-like materials.

In fact, it now appears that Jupiter is a sort of second Sun that never quite made it. Even so it radiates 2 1/2 times as much energy as it receives from the Sun.

Jupiter is huge. It has 11 times the diameter of the Earth, and almost 300 times the mass (or weight) of Earth. If Jupiter had been about three times as large in diameter as it is, it could indeed have become a second Sun, with atomic processes like those of our Sun. Then Jupiter would have appeared brighter to us than our Moon, but not nearly so bright as the Sun, because of its smaller size and much greater distance from Earth. Two-star solar systems are not uncommon elsewhere in the universe. It would have been interesting to have had two Suns here in our own Solar System. It's too bad Jupiter didn't make it.

Speculation has also increased on why Jupiter is so different from Earth, Mars, and Venus. One theory which has been advanced is that Jupiter and the other Outer Planets are the "normal" ones, so to speak, and Earth, Mars, and Venus the "funny" ones. In other words, Jupiter and the other Outer Planets were formed from the same material as the Sun, but Earth, Mars, and Venus are leftovers from some other star that exploded eons ago. According to this theory, we don't even belong to the Sun, except by adoption. We are foreigners as far as our Sun is concerned.

An opposing theory is that all the planets really do belong to our Sun. When the Solar System was formed, the planets made of heavier materials, like Earth, Mars, and Venus, were formed close to the Sun. Those made chiefly of the very light elements, hydrogen and helium, were formed much further out in the Solar System and became the Outer Planets.

I am over-simplifying these theories, of course, but you can see that exploration of the planets does bring up interesting and fundamental questions for the mind of modern man to grapple with.

Outer Planets: Pioneer 11

We have a sister ship of Pioneer 10 on the way to Jupiter now. This is Pioneer 11, which has been underway since April 6 of last year and will pass Jupiter on December 5 of this year.

We have an interesting option in case of Pioneer 11. If we decide we can safely send it much closer to Jupiter than Pioneer 10 went, then it can pick up extra momentum and head off at the right speed and in the right direction to pass fairly close to Saturn in 1979. This is a decision we are still working on.

Outer Planets: Mariner Jupiter/Saturn 1977

Our next spacecraft to visit the Outer Planets, after Pioneer 10 and 11, will be two larger Mariner-type craft, which will be launched toward both Jupiter and Saturn in 1977. These Mariner spacecraft will weigh about 1650 pounds each, compared with only 570 pounds for Pioneers 10 and 11.

They will pass at a considerable distance from Jupiter (more than 200,000 miles) but will come within about 72,000 miles of Saturn. An especial effort will be made to learn more about Saturn's rings and about the moons of Saturn, including the big one named Titan, which appears to be one of the most interesting bodies in the Solar System. At least it appears to have a substantial atmosphere and atmospheric temperatures which might make it what has been called "a place to study prebiological organic evolution".

Our two Mariner spacecraft will have to travel through space for 3 1/2 years before they pass Saturn. Since they are scheduled for launch in 1977, that means they reach Saturn in 1980 and 1981.

Planetary exploration takes patience. It cannot all be done in one big push, like the Apollo program to land on the Moon. We have to move step by step, decade by decade. But even so, a great deal will be learned, and many exciting voyages will be made, during the lifetimes of you young people here today.

Inner Planets -- Venus and Mercury

Now let's come back from the Outer Planets and take a look at the Mariner 10 spacecraft we have headed in the other direction, in toward the innermost planet, Mercury.

Mariner 10 weighs about 1,100 pounds, or twice as much as Pioneer 10.

Mariner 10 passed Venus two weeks ago (on February 5) and used the gravity pull of that planet to send it on toward Mercury. It is the first spacecraft to use this kind of gravity-assist and also the first to head for Mercury.

Mariner 10 will pass Mercury on March 29.

Mariner 10 took about 3,400 pictures of cloud-covered Venus.

These pictures reveal for the first time something of the nature of the weather on Venus. They reveal a system of bands and streaks in the clouds roughly parallel to the planet's equator, and vaguely reminiscent of Jupiter's cloud bands.

Analysis of the masses of scientific data on Venus sent back by Mariner 10 have just begun.

Inner Planets -- Pioneer Venus 1978

Our new Budget, which the President announced earlier this month, calls for two new Pioneer spacecraft to be sent to Venus in 1978. These Pioneers will weigh about 1,500 pounds.

One will send entry probes into the Venus atmosphere at four different locations to measure its composition and global dynamics. These probes will be designed to survive until they reach the surface, but not necessarily on the surface. The second spacecraft will orbit Venus to study the characteristics of the atmosphere and their temporal changes.

This is a project which has had a top scientific priority as the next new step in planetary exploration. Detailed study of the composition and global dynamics of the atmosphere of Venus, which is 100 times denser than the Earth is, will give a better understanding both of Venus and of the forces that drive the Earth's atmosphere, meteorology, and climatology.

The Pioneer Venus missions still have to be approved by Congress.

Mars -- Viking 1975

Now let us turn to what I think will be our most exciting and most significant planetary missions in this decade.

These are two flights by large advanced Viking spacecraft to orbit and land on Mars. They will be launched next year and land in 1976.

The Viking spacecraft weigh 8,100 pounds.

Each Viking consists of two major parts -- an Orbiter and a Lander. While the Orbiters relay communications with Earth and gather other data, the Landers will touch down softly on the Martian surface, transmit TV pictures, and deploy instruments to search for evidence of extraterrestrial life.

It just so happens that the celestial mechanics involved, and the scheduling dictated by budgetary considerations, will permit one of the Vikings to land on Mars on or about the Fourth of July 1976, on the 200th anniversary of American independence.

We hope our Viking landers will be the first to discover uncontestable evidence of life elsewhere in the Solar System. But this honor may go to the Russians.

As you probably know, the favorable opportunities to send spacecraft to Mars come at about two-year intervals. We passed up the opportunity to launch spacecraft to Mars in 1973, but the Russians did not.

The Russians launched two spacecraft to Mars in July of 1973 and two in August.

They call them Mars 4, 5, 6, and 7.

Mars 4 had bad luck. Because a braking rocket failed to function, Mars 4 sailed right on past the planet at an altutude of about 1,400 miles.

Mars 5 has gone into orbit around the planet. (It is in an elliptical orbit with high and low points of about 20,000 miles and about 1,000 miles.)

Mars 6 and 7 will arrive at the planet early in March.

The Russians have announced that Mars 4 and 5 are "analogous" and that 6 and 7 are "analogous". They have not announced which of the spacecraft will send down landers. One guess is that Mars 6 and 7 will attempt landings.

We don't know exactly what instruments the Russians are going to land on Mars. They will undoubtedly have imaging equipment to send back pictures. It is very unlikely that they will have life detection equipment such as we expect to land on Mars in 1976.

Unless there are life forms on Mars big enough to be seen in the Russian TV pictures, it is unlikely that we will know before 1976 whether there is life there or not.

However, if the Russians are successful on their current missions, they should be able to obtain the first detailed pictures of what the surface of Mars looks like.

From our Mariner 9 pictures, which were taken from Mars orbit, we know only the gross features: the canyons, the river beds, the polar ice caps, the volcanos, and features of that sort. We don't know how big the rocks are, we don't know if there are any strange geological formations, and of course we don't know if there are any sizeable life specimens. But these are the things we may learn from the Russian images if they are successful.

Our Viking Landers in 1976 will carry very high resolution cameras plus good biological detecting systems, so we will be able to tell whether there is any living material in the soil near the spacecraft, and also whether there has been any living material in the recent past.

Moreover, we will be landing in regions of Mars which are much more likely to support life than the regions the Russians have chosen to land in this year. The Russians have chosen the landing places that appear most interesting geologically, but less interesting biologically.

We will be landing, for example, in the northern part of Mars (45° N) about 20 degrees from the edge of the north polar cap. We think there is water ice in the polar caps of Mars and we would expect to find the life forms where the water is, or has been. That is, of course, if the life forms on Mars are the same as we know on Earth.

Our other landing will be at the mouth of what appear to have been river beds, in the expectation that water flowing in the past may have deposited elemental organisms of one kind or another in the soil at this point.

Tentative Mars Missions

We have no approved Mars missions beyond the Viking landings in 1976. But according to tentative plans (as set forth in the 1973 NASA Payload Model) we may

-- launch another Viking to Mars in 1979,

-- two new spacecraft to bring back surface samples from Mars in 1984,

-- and two similar spacecraft to bring back samples from the two moons of Mars, Phobos and Deimos, in 1990 and 1991.

In case you are wondering, we have no plans at this time for a manned landing on Mars.

I hope I have already made clear one reason why we don't have such plans. There are so many preliminary missions of great scientific importance to be undertaken first with automated (unmanned) spacecraft. These will keep us busy until the 1990s, at least. A second reason is the high cost. I will come back to this subject later on.

Other Tentative Missions to Explore the Solar System

I would like to tell you very briefly about some of the other tentative plans we have for exploring the planets in the 1980s and early 1990s.

We have tentative plans to send as many as 10 Mariner or Pioneer spacecraft to the Outer Planets in the 1980s. We will explore all the Outer Planets except Pluto, which is too far away.

About 1990 we may send two very heavy payloads weighing about 11 tons each to land a TV camera and other instruments on one of the moons of Jupiter.

In the mid-Eighties we may send two spacecraft to float in the heavy atmosphere of Venus at various levels. And by 1989 we may land a TV camera and other instruments on Venus.

We also have tentative plans to send eight automated spacecraft to the Moon between 1979 and 1991. These include Lunar Rovers which could travel 60 miles or more during a year on the Moon and others which could send samples back to Earth from the hidden side of the Moon.

We also are considering sending automated spacecraft to study comets at close range, beginning in 1979, and perhaps make a landing on the nucleus of a comet. We also want to send automated spacecraft to visit one or more large asteroids in the mid-Eighties.

The Search for Extraterrestrial Life

To conclude my description of NASA's plans, and hopes, for exploring the Solar System, I would like to go a little deeper into one of the great scientific and philosophical undertakings of our time: the quest for extraterrestrial life.

I imagine this is the part of the space program which many of you find most interesting.

Personal Views

I will give you some personal views:

1. There is no hope of finding intelligent life elsewhere in our Solar System. As far as this particular corner of the universe is concerned, we are it.
2. I do think the chances are fair that we will find primitive life forms on Mars or other planets,
   or in their atmospheres,
   or on their moons.

The Search for Extraterrestrial Life

Personal Views (continued)

3. Such a discovery will shed light on how life arose on Earth. It will strengthen our conviction that intelligent life must exist on the planets of millions, or even billions, of other stars in the universe.

4. Will we ever be able to visit other civilizations in space, or expect them to visit Earth?

   I doubt it, in view of the great distances involved.

   We simply do not know how to begin to build the kind of spaceship that would be needed to reach even the nearest stars.

Maybe future generations of Earth men will learn how to build such interstellar space ships.

But first they will have to gain sweeping new insights into the physical laws of the universe. If there are such interstellar spaceships in use elsewhere in the universe, future generations of Earth men may hear about them on the intergalactic radio network, and save themselves a lot of time and trouble.

The Search for Extraterrestrial Life

Personal Views (continued)

5. Although I am pessimistic about the chances of our travelling outside the Solar System, I believe the chances are very good that we can communicate by radio with advanced civilizations in our Milky Way Galaxy or in the many billions of other galaxies in the Universe.

   I find it quite easy to believe that there must be many advanced civilizations broadcasting in our direction -- not to us specifically, but in our direction.

   I am also sure that we have the technology needed -- right now -- to seriously search for and eventually intercept such signals.

   My optimism is based on a serious study made recently with support from NASA. It is called Project Cyclops. It gives very explicit directions for setting up an intergalactic listening system, with present day technology.

Personal Views (continued)

It is simply a question of money, and therefore of public interest.

Such a listening system will probably be set up by today's college students, when you are planning the programs and the budgets of the United States.

It's something to think about. But for the present, we at NASA are already deeply committed

a) to exploring here at home in the Solar System

b) and to making more effective use of Earth orbit for science and practical benefits.

Questions

Now I would like to come back to the questions I usually get asked:

When will Americans return to the Moon?

When will we land men on Mars?

When will we establish a Large Space Station in Earth orbit?

Man's Return to the Moon

It is quite possible that the Russians will send men to the Moon for short stays during this decade, as we have already done in the Apollo program.

Whether we will want to send men back to the Moon on short Apollo-type missions requires further study. It is probably better to wait until we are ready to begin establishment of manned scientific bases for long term use, like our present bases in the Antarctic.

As I see it now, such bases on the Moon are not likely, even after 1991, unless they are built in international projects with the cooperation of the Soviet Union, the United States, and perhaps even Europe. Such bases would be too expensive for one country alone.

Prospects for Manned Mars Landing

I think manned exploration of Mars should be undertaken after we have had experience with large Space Stations in Earth orbit and with long stays in scientific bases on the Moon.

Like scientific bases on the Moon, manned expeditions to Mars will have to be organized on an international basis. They will be too expensive for any one country alone.

Prospects for a Large Manned Space Station

Skylab has clearly shown the potential value of the Space Shuttle and the Spacelab module, which can serve as a small space station accommodating about four scientists for missions up to 30 days.

But Skylab has also convinced us that we will need Large Space Stations for long missions employing larger and more sophisticated instruments.

But we simply do not have the funds in this decade to develop both the Space Shuttle and a Large Space Station. Faced with that choice, we had to give priority to the Shuttle and the smaller Spacelab module.

It is very likely that the Soviet Union will develop a space station, and they may have it in orbit by the end of this decade. How it will compare in size and versatility and productivity with the manned Spacelab module the Europeans are developing for use with the Space Shuttle remains to be seen.

Conclusion

We should not be dismayed by the fact that cost factors require international cooperation on such large undertakings as scientific bases on the Moon and manned landings on Mars. We should welcome it.

I think such cooperation is an excellent way of helping to assure that we will enter the 21st century as a world at peace.

Will such long-term, large-scale international ventures in space be politically feasible one or two decades from now? I very much hope so. No one can say with certainty, of course. But I can point out that we have taken two important steps in this general direction already:

1) The scheduling of the Apollo/Soyuz Test Project for 1975 and

2) The agreement with nine European countries to develop the manned Spacelab module for use with the Space Shuttle.

And by 1991 I anticipate that it will be clear to all that if it is desired to proceed on the major space missions of the future, there is no alternative to international cooperation -- no alternative that is both feasible and appropriate in a world at peace.

It is, of course, difficult to plan now for the future beyond 1991. Our Payload Model goes about as far as one can go.

For the near future -- for the next 18 years -- we do have well planned space programs and possibilities which we can afford on a national basis, which do encourage international cooperation in space on a growing scale, and which are the logical next steps to explore and use space.

The many space achievements we have tentatively planned for the next 18 years will enrich our lives, advance our technology, and enhance our security. They will be achievements that we as a people can be very proud of.